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BEFORE THE

HOUSE ARMED SERVICES COMMITTEE

SUBCOMMITTEE ON STRATEGIC FORCES

ON

STATUS OF BALLISTIC MISSILE DEFENSE TESTING

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Chairwoman Tauscher, Ranking Member Turner, and other members of the subcommittee, thank you for the privilege of appearing before you today on the topic of Ballistic Missile Defense. My testimony today is drawn from reflections on my service to MDA during the last four years as either a member of the Mission Readiness Task Force or the Director for Readiness Assessment. In those capacities, I worked with the test and evaluation communities of GMD, Aegis BMD and THAAD as they prepared for firing exercises in order to provide an independent assessment to MDA/D of their readiness to conduct the missions. Although my testimony is based on these experiences while serving the Missile Defense Agency as a member of The Johns Hopkins University Applied Physics Laboratory, it should be taken solely as my personal view. Neither the Laboratory nor the Agency has approved these remarks, nor have they suggested points to be made in response to the topics for discussion included in the invitation to testify.

After reflecting on the three topics included in the Chair's invitation to testify, I concluded that the nation not only has a military capability that cannot be discounted by a potential adversary, but also is poised to claim even more robust performance that will counter improvements (e.g. countermeasures) in an adversary's basic offensive capability. The next three sections in my testimony will cite factual evidence that should give pause to military planners in countries with a basic ballistic missile capability, endorse MDA's use of Critical Engagement Conditions as a cost effective way to understand the operational effectiveness of the BMDS and outline an opportunity to anticipate design issues affecting the operational suitability of the BMDS. I believe that the observations that I will share indicate that our nation's ballistic missile defense capability cannot be disregarded today and will provide an even more effective defense in the future.

Assessment of Missile Defense Testing Programs to Date

Demonstration of a credible military capability requires successful engagement of threat representative targets flying operationally realistic trajectories by members of the armed forces using production representative systems. Sailors, soldiers and airmen have manned their stations on an Aegis combatant, assumed their posts in a THAAD battery, stood duty in GMD and fulfilled their duties at COCOMs in numerous successful, operationally realistic missile firing exercises. DOT&E has reported these accomplishments in the annual report for FY2008, particularly noting that their firing histories indicate that "Aegis BMD made progress towards demonstrating a robust theater-level missile defense capability against its assigned threats," that "THAAD testing indicates that it will provide a significant increase in capability against short to intermediate range threats…" and that " While GMD has demonstrated a capability against a simple foreign threat, GMD flight testing to date will not support a high level of confidence in its limited capability." Although GMD did not engage a target in FY2008, the firing exercise (FTG05) in December 2008 reaffirmed its ability as demonstrated in its last two intercept missions to deal with a simple separating target. I agree with DOT&E's assessments but note that the reference to "limited capability" by GMD should be applied to demonstrated capability vice inherent capability.

One should note that in these successes (except for FTG05), Aegis, THAAD and GMD essentially operated autonomously to detect, track, engage and intercept the warhead of the target. Aegis succeeded in one exercise against a dual ballistic missile threat raid, succeeded in another while simultaneously engaging a ballistic missile threat and an Anti-Air Warfare threat, shot down an errant satellite and killed a short range ballistic missile threat with an SM2 Block IV missile. Similarly, THAAD has shown a repeatable ability successfully to intercept targets throughout its engagement envelope and GMD's EKV has hit the incoming warhead three times in three attempts. These facts demonstrate that the autonomous functionality and performance in these weapon systems enable their kill vehicles to strike the warheads of unitary or simply separating ballistic threats.

This conclusion does not extend to the oft discussed question of lethality of hit-to-kill; computer simulations must inform our thinking on this matter. Experts on lethality use these simulations during post-mission analysis to determine if the strike line of the kill vehicle on the warhead that was achieved in an intercept would have effected a lethal hit. Consistent results from this post-mission analysis indicate that the kill vehicles, the supporting functionality and weapon system performance for Aegis, THAAD and GMD hold incoming warheads in jeopardy.

I conclude from this evidence that a fundamental, useful defensive capability based on autonomous operation of the Aegis BMD, THAAD and GMD elements is available to our armed forces, but I cannot state that the BMDS has reached maturity. Stable track picture presentation with multiple sensors on line viewing many objects has yet to be demonstrated, bringing weapons to bear based on remote tracks is just being attempted, discrimination of the warhead in a complex target scene and delivering a lethal blow to it will be initially demonstrated in flight later this year, and a finding from DOT&E that the BMDS is operationally effective and suitable is not yet available. I understand that these live firing exercises will add to our demonstrated system capability, but I do not believe that an accurate assessment of system performance can be drawn solely from intercept tests.

Basing BMDS Test Planning and Design on Critical Factors

As mentioned above, demonstration of a credible military capability requires successful engagement of threat representative targets flying operationally realistic trajectories by members of the armed forces using production representative systems. Though necessary, these successful demonstrations will not be sufficient to develop a statistically significant statement of probability of success throughout the regime of scenarios that the system will encounter in the real world. Statistical significance is necessary to narrow the uncertainty in estimates of performance so program managers can budget for procurements that produce the necessary force structure and military planners can develop realistic operational plans.

Let me explain the issue with the following illustration about a coin and whether it is biased towards a particular outcome when flipped:

- Ten flips of the coin produces six heads. Is the coin biased towards heads?
- One hundred flips produces sixty-one heads. One can suspect a bias.
- One thousand flips produces 603 heads. One can be more certain about the probability of a head.

Statistics describes this increasing confidence as a result of more flips of the coin in terms of the number of trials (e.g. flips of the coin), estimate for the variable (ratio of heads to flips), confidence level for the estimate and the width of the confidence interval. For the 100 trials, 61 heads means that the 95% confidence level for the true probability for heads in the coin is between 0.5 and 0.7. For 1000 trials, the 603 heads mean that the 95% confidence interval is between 0.57 and 0.63. The betting line from Las Vegas on the outcome of the next flip of the coin would change as successive flips narrow the interval for the probability that the outcome will be a head.

Firing exercises are obviously more complex than the flip of a coin, but the same statistical concepts apply in order to develop a level of confidence in the performance of a weapon system. Suppose that the **same exact scenario** is repeated ten times and that a successful engagement of the target occurs nine times. The 95% confidence interval for the true probability of success in that one mission based on ten firings (i.e. trials) is between .54 and 1.0. What should program managers and military planners assume as the probability of success? If they assume 0.54, more force structure than might be necessary will be purchased to counter the threat. If they assume 1.0, insufficient force structure might be fielded. Clearly the cost to conduct a firing mission makes it prohibitively expensive to develop a high degree of confidence for the performance of the system for any one scenario, much less the full battle space, using only live fire events.

High fidelity models and simulations offer a much less expensive method to develop statistically significant statements of performance throughout the battle space. For this technique to produce a **believable**, statistically significant statement of performance, the models and simulations must be proven to represent accurately the functional behavior, performance attributes and error sources in the weapon system. That proof (Verification, Validation and Accreditation (VV&A)) comes from a number of experiments and tests, one of which is demonstrating that the results of live firing exercises can be replicated in the model and/or simulation.

MDA is embarked on a task that will determine the critical engagement conditions that will be exercised in live firing events to contribute to VV&A of models and simulations with which to explore system performance. This makes sense to me, especially if DOT&E is aware of the methodology, contributes an operational perspective to the Critical Engagement Conditions and agrees that it will produce an effective tool with which to develop a finding concerning the operational effectiveness of the BMDS. This Critical Engagement Condition methodology makes even more sense to me if it offers an opportunity to define an associated ground test campaign that DOT&E is willing to accept as a tool with which to develop a finding concerning the operational suitability of the BMDS. Including a ground test demonstration of operational suitability as an integral part of the output of the effort is important if it enables MDA to plan the simplest possible set of live firing missions.

"Simplest" does not mean simple; it means "use the minimum number of elements" that are necessary to serve the critical engagement condition(s) being addressed in that flight test. The cost to launch a ballistic missile target demands careful planning and execution to produce the desired technical results with the minimum amount of risk to maximize the return on the investment. Predicting the probability of success for the mission, an important facet in planning with which to understand risk, becomes more time consuming as the architecture for the system under test becomes more complex. Experience gained to date in preparation for the last two GMD missions indicates that predicting the probability of success can be a very long pole in the pre-mission schedule for a multi-element test. DOT&E's FY2008 Annual Report notes that "the ground test program has advanced faster than flight test program can provide validation data for the models and simulations upon which ground testing relies…" Prudent preparation for flight tests will continue to slow the pace of intercept missions if a maximum number of elements of the BMDS is included in each firing exercise.

A minimalist approach to flight testing can increase the frequency of flight tests, but will limit the opportunities to bring the entire BMDS into play and thus reduce the opportunities for DOT&E to observe the full BMDS in operation. Without such opportunities, I would find it difficult to decide if the full system's behavior was clumsy or graceful, if displays for the operators were intuitive or arcane, or if human interaction with the system was facile or difficult. A minimalist flight test approach can increase test tempo, but can be correctly criticized as not demonstrating full BMDS operation. This potential criticism from DOT&E was the motivation for the recommendation above in which a ground test campaign would be used to determine the operational suitability of the BMDS.

Future Actions

A ground test campaign to demonstrate operational suitability must exercise the complex interactions, or interoperability, between elements of the BMDS. Interoperability involves maintaining a consistent track picture in all command and control portions of the BMDS, ensuring that tracking uncertainties are properly reflected in fire control solutions that depend upon them, knowing that shifts in reporting responsibilities for tracks by sensors is recognized throughout the BMDS, employing consistent interpretations of the protocols that govern the exchange of information over data links, etc. etc. Interoperability is a tricky business when one tries to make function as one BMDS, a family of elements each with their own autonomous capability. Since the natural focus for forming the BMDS from the elements is the C2BMC suite being developed by MDA, care must be taken to ensure that its functionality meshes cleanly with that of GMD, THAAD, Aegis BMD, et al. One must take care to ensure that C2BMC's implementations do not confuse the operation of the BMDS when it fields a function such as system track development that is similar to a pre-existing function in the elements. Competing responses from these similar functions can propagate over data links to produce different track pictures within the BMDS with attendant confusion over what object to engage. Care must be taken to ensure that the BMDS is interoperable if one expects DOT&E to find that it is operationally suitable.

The missions in which I have participated to date have employed limited functionality by C2BMC. Preliminary results from the last GMD intercept and initial predictions for the upcoming Aegis mission uncovered some issues with this limited implementation that prompted me to recommend to the system engineering team an effort to anticipate other issues that might be in the offing. That activity would:

- Poll all the elements' understandings of the requirements of the standards governing the data links and resolve any differences within the BMDS.
- Convene a table top exercise with a red team mentality whose objective is to anticipate potential interoperability issues when the full suite of C2BMC functionality is in place. Define implementations which resolve any issues and explain the sequence in which those implementations should occur. Pay special attention to resolutions requiring cooperation among elements.

As noted above, the possibility of a ground test campaign to complement the "minimalist" set of firing exercises expanded my thinking on this interoperability effort to include:

- Confer with DOT&E to develop a series of ground tests with which the operational suitability of the BMDS can be demonstrated.
- Develop a systematic sequence of test events using ground based HWIL assets that demonstrates first that parts of, and eventually that all of, the BMDS are interoperable. (The intent of this plan is to prepare the system for the DOT&E endorsed series of tests from which an assessment of operational suitability will be drawn. Reserve time in the plan to resolve issues as you move from event to event.)

- Identify the necessary modifications, if any, to the current ground test program.
- Obtain the endorsement of the plan from the Director of the Missile Defense Agency, then execute.

To succeed, this effort must have the support of the Director, the cooperation of the elements and expertise with which to meets its obligations. All are available within MDA.

In this scheme, ground tests focus on interoperability while flight tests anchor the models and simulations with which to ascertain effectiveness. Although these two regimes, ground tests and flight tests, are designed to produce a finding of "operationally effective and operationally suitable," there is potentially a subtle difference in their execution. A minimalist flight test plan could be mostly element centric with only a few firing exercises involving multi-element operations and even fewer involving the total BMDS. Such a plan would definitely be paced by the availability of system improvements from the firing elements (e.g. Baseline 4.0 for Aegis BMD , CEII EKV for GMD, et al) and only loosely tied to developments within C2BMC. Conversely, the DOT&E endorsed ground test definitely cannot occur until the interoperability plan has completed. The interoperability plan, and consequently the ground test to demonstrate operational suitability, will definitely be paced by the development cycle of C2BMC.

This subtle difference can be used to advantage by first coupling the two test regimes at the point where the interoperability plan would be nearing completion. Initially the two test regimes do not depend upon one another to progress to the next events, but at an appropriate point one can imagine that an event in the DOT&E endorsed ground test would also serve as a rehearsal for an intercept test. Exploitation of such an advantage requires thoughtful planning of the activities for the two test regimes that recognizes the necessary alignment of the programs of record. As one approaches the "operationally suitable" series of events, the ground tests must be utilizing element configurations that represent a defined block of capability to be delivered to the armed forces and the flight tests must have addressed all the Critical Engagement Conditions for that block.

This approach does not guarantee success, but does allow room for different fielding decisions if one of the test efforts significantly outpaces the other in attaining its goal. If flight testing proceeds well ahead of ground testing, one has the option of deploying improved performance within a paradigm of essentially autonomous operations by the firing elements with C2BMC continuing to provide situational awareness for the COCOMs. If ground testing finishes well ahead, one can field the matured C2BMC if the requisite functionality is available within the other elements or wait until they catch up. In all events there are options, but this complementary ground test and flight test strategy is viable only if a "minimalist" approach to flight testing arises from the Critical Engagement Conditions effort.

<u>GMD</u>

Chairwoman Tauscher, you asked me for specific comments about how to ensure that GMD will work in an effective, suitable and survivable manner. Two important points made by RADM Paige in her after action report on the activities of the Mission Readiness Task Force (MRTF) bear directly on the answer. The admiral noted in her first point that GMD had adopted the disciplined flight test preparations demonstrated to them by the members of the MRTF. I can assure you that GMD inculcated the discipline embodied in the phrases “fire to verify, not to discover” and “test as you fight.” In its last four missions, GMD has prepared for flight tests with a sense of urgency but has not cut corners in the name of schedule. GMD conducted those missions when preparations were complete and utilized the equipment that is available to the armed forces to detect the target, process the engagement and intercept the warhead. GMD is doing the same for its upcoming firing test. RADM Paige noted in her second point that the inherent performance of GMD can only be as ready for service as the reliability of the system allows it. GMD heard that message and incorporated quality improvement provisions in its contracts to industry. Time will tell us what benefits are reaped from that contractual action. Until then, I respectfully urge the committee to support the testing discipline and the quality initiatives that are a part of GMD’s culture.

Closing Thoughts

In summary, I have made the following points:

1. Our armed forces possess a credible ballistic missile defense capability.
2. MDA is poised to demonstrate an even more robust capability.
3. MDA is redefining flight tests using thoughtful Critical Engagement Conditions as a means to anchor high fidelity models and simulations that can be used to assess the operational effectiveness of the BMDS.
4. The redefined flight tests might offer an opportunity for a complementary series of ground tests with which to assess the operational suitability of the BMDS.

In closing, let me again thank you for the opportunity the testify and to thank each one of you for your service to the nation.